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HAY CROP SILAGE

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SUMMARY

In recent years many farmers have made and fed silage from hay crops and have accepted it as an important form of forage that can be readily used in livestock rations. The potential value of hay crop silage is only beginning to be realized, and much remains to be learned about the processes involved in making good silage. However, the steadily growing popularity of the feed has brought about widespread experimentation by farmers and scientists in regard to new methods of harvesting, handling, storing, and feeding. Contributions by both groups account for silage methods now in use.

Briefly, research and experience have shown that hay crops become silage as a result of fermentation of carbohydrates in the forage. The fermentation is accomplished through bacterial action. Organic acids are produced during this process and certain of these acids preserve the silage. Oxygen must be excluded from ensiled forage in order to produce good silage. Different structures can be used for storage, with varying losses of silage nutrients and dry matter. Good silage can be made by either proper wilting of the forage or the use of preservatives. It can be fed on an equivalent dry-matter basis to replace hay. It usually contains more protein than corn silage, but somewhat less total digestible nutrients.

This report summarizes results of research and experience of the U. S. Department of Agriculture in making, storing, and feeding silages produced from hay crops.

Information in this report was provided by the Animal Husbandry Research Division, Agricultural Research Service

HAY CROP SILAGE

Since World War II hay crop silage has rapidly become recognized as an important feed for livestock. Farmers in all areas of the United States produced an estimated 9.3 million tons of the silage in 1955.

Experimental work on methods of making silage from hay crops was begun by the U. S. Department of Agriculture more than 25 years ago. Research workers applied principles that actually date back to Biblical times in attempts to produce silage from fresh green grass, either alone or mixed with legumes, by wilting and chopping the crop and storing it in silos. Results of these early tests were erratic. Sometimes the silage that was formed was highly palatable, lost little dry matter or carotene, and had an agreeable odor. Often, however, the process was a failure.

During the past quarter-century, Department and State Agricultural Experiment station workers have proved that good hay crop silage is a superior source of carotene and often is equal to or surpasses field-cured hay in feeding value. Also, during that time research and experience have provided new silage methods and machinery. Now, using modern techniques, hay crop silage can be made on any farm with reasonable assurance of success.

A growing interest in harvest methods that protect forage from weather damage and help save feed nutrients has been a major reason for the popularity of hay crop silage. Forage crops can be harvested for silage in weather that is too cool and too damp for haymaking, thus avoiding weather damage and harvest losses. Leaf shattering is prevented because forage plants are quickly removed from the field, ensiled, and preserved by their own fermentation in airtight storage.

Using the silage method can save about 80 to 85 percent of the original feeding value of plants. This can be accomplished with about the same labor and equipment (with the substitution of a forage chopper for a hay baler) that is needed for ordinary haymaking operations. A principal advantage of silage over hay is the saving of nutrients while harvesting and handling the crop. This was illustrated during a 5-year study at the Agricultural Research Center. Field-cured hay lost on the average 1.6 times as much dry matter, 2.1 times as much protein, and 1.2 times as much carotene between cutting and feeding as did wilted hay crop silage.

Variety in the feeding program is provided when the first cutting of hay crops is harvested early as silage, and later cuttings as hay. Harvesting a crop at an early stage of growth for silage also provides forage that is at or near its peak content of carotene and protein. In addition, early harvest of the first cutting as silage usually results in a heavier second cutting of the hay crop.

HOW HAY CROP SILAGE IS FORMED

Green hay crops become silage as the result of several actions that take place after the crop is in the silo. Formation of good silage involves

the activity of bacteria and enzymes and the respiration of plant cells of the green crop.

During fermentation the combined activity of plant and bacterial enzymes breaks down carbohydrates into alcohol, carbon dioxide, water, and acetic, lactic, butyric, and other organic acids. Proteins also are partially broken down by the enzymes into amino acids, peptides, and ammonia.

As the activity of plant cells slows down, the activity of anaerobic bacteria in the forage increases. A bacterial population that is able to quickly produce and maintain a predominance of lactic acid in the fermenting forage is desirable for producing good silage. This acid condition in the forage discourages growth of undesirable bacteria that cause rotting and spoilage.

The accumulation of lactic acid in the forage is most rapid when there is no oxygen present, moisture content of the forage is from 65 to 70 percent, and there is a plentiful supply of available carbohydrates (sugars) that may be used for food by bacteria. Normally, these conditions result in a temperature rise in the forage to around 80° to 100° F. within a week after ensiling.

When no air leaks occur silage cools slowly and steadily until it approximates the outside temperature. The cooling indicates that most bacterial activity has slowed down, and that acid conditions have been formed that will preserve the silage. As long as air is kept out, the silage will remain preserved. If too much air enters the ensiled forage, a low lactic acid silage is formed. Too much air in the forage may be caused by coarse chopping, poor packing, or faulty storage facilities that allow air to enter.

The bacterial and chemical actions that change the hay crop into silage are responsible for loss of nutrients and dry matter, some of which cannot be avoided by presently used methods. Gaseous losses amount to 5 to 10 percent of the total nutritive value of well-made silage, and will be higher if air invades the silage and causes heating to occur. Thorough packing and effective sealing of the forage can keep gaseous losses at a minimum.

FORAGE PLANTS FOR HAY CROP SILAGE

Good hay crop silage can be made from any adapted, high-yielding forage crop that is suitable for hay or pasture. Grasses, legumes, and cereals, or mixtures of these crops that are good feeds when green or when made into hay also are good feeds when made into silage. Making silage of these crops does not increase their nutritive content. The process simply preserves a high percentage of the nutrients present in plants.

The kinds of plants used for hay crop silage help slow water runoff, an important factor in hilly areas where the growing of row crops may cause serious soil erosion.

Forage plants harvested for silage include alfalfa, the clovers, soybeans, cowpeas, vetch, Sudangrass, orchardgrass, bromegrass, timothy, and other grasses. Legumes, or grass and legume mixtures, usually make

more nutritious silage than do grasses alone. Multiple-use crops that are grown for hay, pasture, or silage may be made up of such combinations as alfalfa with bromegrass, alfalfa with timothy, or orchardgrass with Ladino clover and red or alsike clovers.

The amount of small grains made into silage has increased in recent years. More total digestible nutrients per acre can be obtained from immature small grains harvested for silage than from those harvested for grain because the entire plant is used in silage. When small grains sown for cover crops are harvested for silage, their early removal benefits the underseeded grasses and legumes.

STAGE OF PLANT MATURITY FOR HARVEST

The trend in recent years toward earlier harvest of hay crops for silage may be traced to the growing appreciation for the high nutrient content, greater palatability, and larger consumption by livestock of immature plants. The feeding value of nutrients in a forage crop and the moisture content of the crop are highest at an early or pasture stage of growth. As the crop matures, the plants contain less moisture. They have the least moisture and therefore the highest content of dry matter at the late-bloom stage of growth.

The correct stage of maturity to harvest hay crops for silage is the same as the most advantageous stage for making hay. Legumes for silage are cut in the early bloom stage. Grasses are cut before bloom. The correct time for harvest of mixtures of grasses and legumes is determined by the predominating plant species. This recommendation represents a compromise in regard to yield of dry matter, palatability, and digestibility that provides a reasonably high yield of good forage that should be readily eaten.

Soybeans, lespedeza, and cowpeas are cut soon after the first seed pods have filled. Cereal crops, such as oats, wheat, and barley, may be cut anytime from early flower to milk stage.

MAKING HAY CROP SILAGE

Hay crop silage is made either from forage that has been partially dried in the field by wilting, or from wet forage that has been cut and chopped by a direct-cut forage harvester and ensiled immediately. Good silage can be made using either method.

Silage From Unwilted Crops

Unwilted or high-moisture silage is a relatively recent development that has become more common with the expanding use of direct-cut harvesters. In the past some wilting of hay crops for silage always occurred, either intentionally when forage was left to dry in the windrow, or unintentionally during cutting, loading, hauling, chopping, and ensiling. Now, however, direct-cut harvesters eliminate opportunity for field wilting by combining cutting, chopping, and loading operations so that a crop does not touch the ground between cutting and ensiling. Elimination of wilting reduces the chances of nutrient losses in the field from exposure to the elements.

The farmer who makes unwilted silage obviously handles more weight in the form of water to store an equivalent amount of dry matter than the farmer who makes wilted silage. For example, to store 35 tons of silage dry matter, it is necessary to ensile only 100 tons of wilted forage containing 65 percent moisture. However, to store the same amount of dry matter in unwilted silage containing 80 percent moisture, 175 tons of forage must be ensiled.

In the silo the weight of high-moisture forage presses nutritious juices from leaves and stems of hay plants and forces this liquid to seep from the bottom of the silo. Seepage fluids contain highly digestible protein and ash constituents and have a dry-matter content ranging from 4 to 10 percent. Attempts to reclaim some of this dry matter by recirculating seepage fluids through silage have proved ineffective.

Undesirable fermentation is often associated with high-moisture, direct-cut forage. However, undesirable fermentation can be reduced or overcome entirely through use of chemicals as preservatives and seepage losses can be lessened or eliminated by use of feedstuffs to soak up moisture. Chemical preservatives artificially create some of the conditions necessary for good fermentation, and dry ground feedstuffs soak up moisture, thus reducing the moisture content of the forage.

Table 1 indicates the time and labor, in terms of hours per ton of dry matter, required for harvesting both wilted and direct-cut forage for silage at the Agricultural Research Center, Beltsville, Md., 1955 through 1958.

TABLE 1.--Time and Labor Requirements for Harvesting Alfalfa Silage

(Hours per Ton of Dry Matter)[1]

Machinery	Wilted forage 65.5 percent moisture[2]						Direct-cut forage 75 percent moisture[3]	
	Method A[4]		Method B[5]		Method C[6]			
	Machine	Man	Machine	Man	Machine	Man	Machine	Man
	Hours	*Hours*	*Hours*	*Hours*	*Hours*	*Hours*	*Hours*	*Hours*
7-ft. mower	0.49	0.49	--	--	--	--	--	--
7-ft. rake	.43	.43	--	--	--	--	--	--
7-ft. mower-rake	--	--	0.59	0.59	--	--	--	--
12-ft. windrower	--	--	--	--	0.20	0.20	--	--
5-ft. forage harvester:								
Windrow attachment	.33	.33	.33	.33	.33	.33	--	--
Direct-cut	--	--	--	--	--	--	0.66	0.66
Silo filler	.27	.27	.27	.27	.27	.27	.34	.34
Total	1.52	1.52	1.19	1.19	.80	.80	1.00	1.00

[1] Average results USDA, Agricultural Engineering Research Division, Beltsville, Md., 1955 through 1958.
[2] Yield 0.82 ton dry matter per acre from 75.6 acres.
[3] Yield 0.76 ton dry matter per acre from 29.4 acres.
[4] Consists of using mower, rake, forage harvester with windrow attachment, and silo filler.
[5] Consists of using mower-rake (single operation), forage harvester with windrow attachment, and silo filler.
[6] Consists of using windrower, forage harvester with windrow attachment, and silo filler.

Although the direct-cut method of harvest simplifies operations by eliminating the need for mowing and raking, it may not speed up the rate of harvest. A forage crop cannot be removed from the field at a rate faster than that at which the forage harvester operates. Table 1 shows that dry matter is harvested from wilted windrows at a rate (0.33 hour per ton) twice as fast as from a standing unwilted crop (0.66 hour per ton of dry matter). There are two reasons for this: (1) The direct-cut harvester cuts a relatively narrow swath; and (2) extra power is required to handle the excess moisture in unwilted forage. When mowing and raking are combined (Method B), total labor and machinery requirements for harvest of wilted forage approach those for direct-cut forage. When a windrower is used (Method C), requirements for wilted forage are less than for direct-cut forage.

Hauling high-moisture forage during harvest usually requires more time and labor than hauling wilted forage. For example, if a 4-ton capacity wagon is used during harvesting and storage of 35 tons of forage dry matter, only 25 loads of 65-percent moisture wilted forage must be hauled. On the other hand, about 44 loads of 80 percent moisture direct-cut forage must be hauled to store the 35 tons of dry matter.

Preservatives for Unwilted Hay Crop Silage

High-moisture forage occasionally produces an excellent natural fermentation without the addition of a preservative. The conditions necessary for this are not fully understood and are impossible to predict at this time. Therefore, use of a preservative is recommended on all immature, high-moisture forage for silage in order to help create conditions that are favorable to fermentation.

Preservatives may bring about favorable conditions in a variety of ways, depending on the kind of preservative used. They may provide readily available sugars for bacterial food, create an acid medium that hampers the growth of undesirable bacteria, absorb excessive moisture in the forage, inhibit the development of specific groups of undesirable bacteria, or do a combination of these things. Use of a preservative does not lessen the need for effective packing and sealing of the forage from air invasion.

Chemical Preservation of Unwilted Hay Crop Silage.--Materials which preserve hay crop silage through chemical action have been the subject of much research and study, and the pattern of their use is constantly changing. Some successfully preserve silage but are unsatisfactory because of inconvenience, personal hazard, or expense. The discussion that follows is limited to observations resulting from study of several preservatives by USDA workers.

Sodium meta-bisulfite ($Na_2S_2O_5$) is a dry chemical powder that releases sulfur dioxide gas on contact with moisture in forage. The gas combines with moisture to produce sulfurous acid which reduces plant respiration and excessive fermentation. It may be distributed at the blower or elevator by using a fertilizer drill attachment operated at a slow speed by a small electric motor. Although results of tests at the Agricultural Research Center were variable, sodium meta-bisulfite generally was found to be safe, convenient, and relatively inexpensive.

Hay crop silage from high-moisture forage treated with sodium metabisulfite usually has a characteristic good odor, retains more carotene and sugar than untreated silage, and is slightly more palatable than the untreated.

Recommended rates of application are 8 to 10 pounds of sodium metabisulfite per ton of green crop. If more than 10 pounds are applied per ton of crop, silage may be unpalatable.

Kylage[1] is a patented preservative material. An analysis of high-moisture hay crop silage treated with Kylage at the rate of 5.1 pounds per ton of crop at the Agricultural Research Center indicated that quality of the silage was improved over poor quality, untreated silage. Kylage-treated silage appeared to be more palatable than the poor quality untreated silage. Kylage may be applied in the same manner described for sodium metabisulfite.

Materials that have been found to have little or no desirable effects or practical value as preservatives include urea, dry ice, salt, cultures of lactic acid bacteria added with or without salt, and seepage fluids collected and recirculated through the silage.

Feedstuff Preservation of Unwilted Hay Crop Silage.--Feedstuffs, including ground grains and molasses, are commonly used as aids in preservation of unwilted hay crop silage. Feedstuffs include crushed or ground ear corn, crushed cobs, ground oats, corn, or barley, mixed grains, brewers' and distillers' grains, dried beet pulp, dried citrus pulp, and others.

Feedstuffs improve hay crop silage in three ways: (1) by absorbing excess moisture and reducing or eliminating seepage, (2) by adding to the feed value of the mixture, and (3) by providing available food for bacterial growth. Feedstuffs also improve palatability of silage. From 75 to 80 percent of the feed value of these preservatives remains in the silage.

Tests of several feedstuffs at the Agricultural Research Center indicated that citrus pulp, beet pulp, and ground hay had the best water-holding capacity of those tested; dried distillers' grains were intermediate in this capacity, and ground cereal grains were poorest.

Ground grains or other concentrates may be added at rates varying from 100 to 200 pounds per ton of forage, depending on the moisture content of the forage at the time of ensiling. The 200-pound rate is recommended for forages containing from 80 to 85 percent moisture; the 100-pound rate for crops with 75 to 80 percent moisture.

In other tests at the Research Center, both corn meal and dried beet pulp improved nutrient preservation and feed value of high-moisture silage from hay crops when added at the rate of 200 pounds per ton of crop. However, cattle fed the silages that contained the feedstuff preservatives consumed less hay-crop dry matter than cattle fed wilted silage without preservative added. The forages with feedstuff preservatives added actually contained less than two-thirds dry matter in the form of hay-crop silage; the remainder of the dry matter was made up of the feedstuffs added for preservation.

Feedstuffs take up excess moisture and are useful in silage preservation. On the other hand, whether adding them to forage represents the most

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[1] The primary constituent of this material is calcium formate. However, the manufacturer attributes some of its action to the relatively small amount of sodium nitrate this product contains.

efficient use of silage storage space is a question that should be weighed and answered by the individual farmer. For example, to bring the moisture level of forage from 80 to 70 percent, about 330 pounds of dried beet pulp is added per ton of forage. The beet pulp then makes up more than 40 percent of the total dry matter in the silo. Also, if feedstuff preservatives are purchased, there is a cash outlay in the spring for the following winter's feed supply.

Molasses improves unwilted hay crop silage fermentation by providing readily available sugar for growth of the bacteria that produce lactic acid. It may be applied in either liquid or dehydrated form as forage enters the cutter or blower. Both forms improve the palatability of silage and increase its nutritive value.

Liquid molasses is applied at rates ranging from 80 to 100 pounds per ton of crop, depending on the moisture content of the forage. The 80-pound rate is recommended for crops with around 75 percent moisture, and the 100-pound rate for crops with 80 to 85 percent moisture. Dehydrated molasses may be applied in quantities that supply carbohydrates at the same rates as in the liquid applications mentioned above (equivalent carbohydrate basis).

Silage From Wilted Crops

Wilting can be used to bring the average moisture content of fresh-cut forage within the 65- to 70-percent range considered best for good natural fermentation. This reduces the weight of the crop to be stored and eliminates the need for preservatives in tower silos. Generally, the moisture content of most hay crops must be lowered by 10 to 15 percent after cutting to be within the ideal moisture range. However, the fresh-cut crop may be within the range without wilting during droughts or when the hay crop is cut at a later stage of maturity than is recommended for good silage.

The wilting method is flexible enough that silo filling can proceed uninterrupted even though all forage is not within the 65- to 70-percent moisture range. While the average moisture content of all forage should be within this range, individual loads of forage may be as low as 50 percent moisture, particularly if this forage is placed in the lower portion of the silo. On the other hand, occasional loads of forage that contain more than 70 percent moisture cause no apparent difficulty.

The common tendency is to wilt a crop too much rather than too little. If average plant moisture content is allowed to go below 60 percent, molds and overheating may occur in the silo, causing nutrient losses. The time required for wilting varies with the original moisture content of the crop, thickness of windrows, and weather conditions. During a good drying day, when the sun is shining, the humidity is low, and a breeze is blowing, the crop may be ready for ensiling after 1 or 2 hours in the windrow. During damp weather, however, forage may lie in the field for 2 to 3 days before reaching the optimum moisture content.

Determining Forage Moisture Content

There are a number of ways to determine whether forage has been wilted enough to be ensiled. However, some methods are too complex for

farm use. One practical method for obtaining a rough estimate of forage moisture content without special equipment is called the "Grab Test." Forage used in the test should be taken from windrows that are representative of the entire crop.

Fine-chopped forage similar to that obtained from 1/4-inch or 3/8-inch cutter setting should be used in making the test. Compress the forage into a ball between the hands for 20 to 30 seconds, then release the ball suddenly. The condition of the ball of forage immediately after it is released roughly indicates the amount of moisture present. (See table 2.)

Table 2.--Determining Forage Moisture Content by the Grab Test

Condition of forage ball	Approximate moisture content
When the ball holds its shape and there is considerable free juice....................	Over 75 percent
When the ball holds its shape but there is very little free juice	70 to 75 percent
When the ball falls apart slowly and there is no free juice	60 to 70 percent
When the ball falls apart rapidly	Below 60 percent

FILLING THE SILO

A primary objective in silo filling is to pack and seal forage in a way that will result in good fermentation and prevent spoilage during storage. Methods of filling should be adapted to the type of silo used for storage. Hay crop silage can be made and stored successfully in covered stacks, bunkers, trenches, and fence silos, as well as in permanent upright silos, such as conventional tower silos and gastight steel silos.

The main requirement for successful storage in any type of silo is exclusion of air. This is accomplished when air is forced out or used up during fermentation, and kept out during storage. Spoilage of silage from exposure to air may occur at tops and sides of silos, as well as within the stored forage. It may be caused by inadequate packing, air leaks in covers on horizontal silos, or cracks in the walls and around doors of tower silos. Excess air causes silage to heat, and nutrients are destroyed as a result of oxidation.

In horizontal silos, top and side losses can be kept at a minimum by effective use of plastic covers (as described in another section of this report) and thorough packing of the forage. Top losses in tower silos can be virtually eliminated when the top of the forage is covered with a cap made of plastic sheeting.

Side losses can be minimized in tower silos by eliminating cracks in walls and sealing doors.

Filling Upright Silos

Conventional tower silos, gas-tight steel silos, and temporary fence silos may be filled with either a blower or an all-purpose farm elevator, depending on the height of the silo.

Measures required for successful storage of hay crop silage are the same as those required generally for other kinds of silage: Air is excluded, forage is thoroughly packed (except in gas-tight silos), and the top of the ensiled material is covered or sealed to prevent losses of nutrients and dry matter.

Tower silos built for corn silage may require reinforcement when filled with unwilted hay crop silage because they are subject to greater pressures from the heavy forage than from corn silage.

Gas-Tight Silos

Gas-tight silos are made of steel that is coated with a glass-like substance. They are designed for storage of wilted or even overwilted forage with as little as 40 to 50 percent moisture content. These silos may be partly filled on widely separated dates, provided they are sealed between fillings. Packing and tramping of forage is not necessary, although some leveling is desirable.

Practically all outside air is kept out of the gas-tight silo and carbon dioxide formed during fermentation is kept in. A plastic breather bag and a pressure relief valve located in the top of these silos compensate for differences in inside and outside pressures without allowing outside air to contact the forage. Experience at the Agricultural Research Center indicates that before each filling the plastic breather bag should be checked for holes and flaws and pressure relief valves should be inspected for fouling by dirt and forage.

Conventional Tower Silos

Either wilted or unwilted hay crops can be made into good silage in conventional tower silos. However, different procedures are used for ensiling these two types of forage.

Wilted silage can be ensiled rapidly without preservatives. The usual procedure consists of filling the major portion of the silo with wilted forage and topping out the silo with unwilted forage.

If the forage to be placed in a tower silo is unwilted, either a chemical or a feedstuff preservative should be added. As explained earlier, chemical preservatives promote good fermentation but do not reduce seepage of silage fluids. Seepage can be eliminated, or reduced, through use of feedstuff preservatives.

Forage that is extremely dry (below 60 percent moisture content) because of drought, overwilting, or advanced maturity, should be chopped at a fine cutter setting (not exceeding 1/4 inch) and ensiled immediately. The fine forage can be readily packed to force out air and prevent heating

and formation of molds. Forage wilted to contain 60 to 70 percent moisture should be chopped at the finest cutter setting (1/4 to 1/2 inch).

Regardless of whether wilted or unwilted forage is ensiled, storage conditions in tower silos are aided by even distribution, thorough packing of the forage, and use of a top cover. Plastic caps now available avert top spoilage by preventing the entrance of air. Heavy forage or seeded oats also may be used for top cover. Except when a plastic cap is used, forage should be tramped at the edges for several days following filling.

Proper condition of the tower silo is also important. In addition to having sufficient strength to withstand pressure exerted by hay crop silage, silo walls should be cylindrical, smooth, and airtight.

Fence Silos

Forage placed in fence silos should be kept level and well packed as each tier of fencing is telescoped into place and filled. The height of a fence silo should not exceed its diameter by more than 4 feet.

Without an airtight lining of some type, large amounts of spoilage will occur in fence silos. Plastic linings have been particularly effective in reducing spoilage. The lining may be lapped over the top of forage that has been arched slightly and will form a top cover that sheds rain and snow.

Filling Horizontal Silos

Trenches, bunkers, and stacks are usually filled by dumping forage from conveyor-type wagons, trucks, or buck rakes. A blower is not needed for filling, although one may be used when preservatives are applied.

These relatively low-cost storage facilities have made production of silage from hay crops practical for farmers who do not have tower silos or the equipment ordinarily considered essential for making and feeding silage. The silage is easily accessible and may be self fed direct from the silo. Either long or chopped forage can be ensiled, although packing and air exclusion are more difficult with long forage unless it is quite high in moisture content.

Machinery is driven over the forage as it is ensiled to facilitate filling and to insure adequate packing. The size of this machinery usually governs the minimum width of a silo. Depth of trench silos is governed by the depth of the water table. The bottom of the silo should not be below the water table level.

Horizontal silos should be quickly filled and covered. Even distribution of forage and constant packing with machinery are essential for successful silage-making in these structures. Generally, only unwilted, immature hay crops are stored for silage in horizontal silos. However, wilted forage that is placed in a trench silo may be successfully made into grass silage if special attention is given to constant packing and to obtaining an airtight seal with an effective cover.

Forage on the tops of stacks, bunkers, and trenches is rounded to shed rain and snow. Tops of trenches should be above ground level to prevent collection of water in the silo and water-logged silage.

Trenches and bunkers are made wider at the top than at the bottom to allow forage to pack tightly against the walls as it settles and, in the case of trenches with dirt sides, to prevent the sides from caving.

Covers can be kept in place more easily on stacks with sloping sides than on vertical-sided stacks. Experience with tractor-packed stacks shaped like an elongated, inverted saucer indicated that surface losses were small because the cover weighting material (sawdust) remained in place on the gently sloping sides of the stacks.

Since dry-matter losses occur mainly around the outside of stacks, larger stacks lose proportionately less than smaller ones.

Success with silage in horizontal silos hinges on how closely recommended filling and sealing procedures are followed. Minor deviations from these procedures can result in high losses from spoilage. However, if close attention is paid to packing and sealing, losses of dry matter and nutrients in trenches, bunkers, and stacks will be no higher than losses experienced with well-handled upright silos.

Plastic Covers for Horizontal Silos

Plastic films or covers, properly used, are very effective in preventing nutrient and dry-matter losses in horizontal silos.

Use of plastic covers can overcome the most serious disadvantages of horizontal silos encountered in the past: nutrient and dry-matter losses caused by spoilage of forage in the large surface area exposed to the weather, and leaching of nutrients by rain and snow.

Practically all spoilage in fence silos can be eliminated by lining them with plastic coverings, which are available in the form of prefabricated sleeves.

In recent tests, total dry-matter losses in horizontal silos sealed with plastic covers were as small as the losses experienced in efficiently handled tower silos--10 to 15 percent. The plastic saved about three times the cost of the material. These results were obtained when a layer of sawdust about 4 inches deep was spread over the entire surface of the plastic covers. The sawdust minimized effects of punctures in the covers by limiting the amount of air that entered small holes, by providing a constant pressure on the cover as silage settled, and by maintaining a seal on the remainder of the silo after one end was opened for feeding. The covers were weighted at the edges with soil.

Only 5 percent spoilage occured in a shallow stack of chopped, untreated orchardgrass covered with a 4-mil polyethylene sheet with heat-sealed seams. Least spoilage in bunkers was in orchardgrass silage covered with neoprene-coated nylon. Poorest results in these tests were obtained when plastic sheets were weighted only at the edges and air leaks developed. Plastic films supported with nylon were more durable and less subject to damage during handling than unsupported films.

↑ N-25638

Figure 1.--Above, the procedure and material used in covering a horizontal silo have an important influence on the amount of spoilage in hay crop silage stored in these structures. Forage should be covered as soon as the last load is thoroughly packed. Polyethylene and vinyl plastic films and neoprene-coated nylon fabric covers have proved efficient in preventing losses in silage from air invasion in ARS tests.

← Figure 2.--Left, covering the edges and ends of the silo cover with soil to help seal out air and prevent wind from lifting the cover. Note: Some covering materials may be damaged if walked on.

N-25642

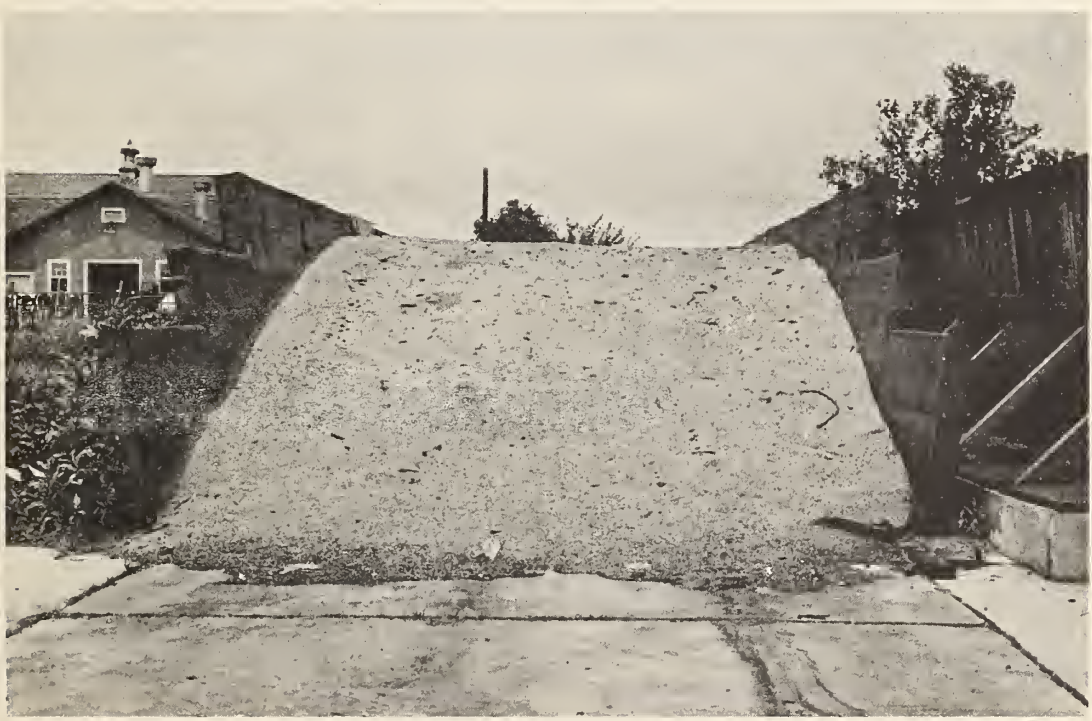

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Figure 3.--Above, spreading a 2- to 3-inch layer of sawdust to provide a weighting material over the cover. Below, the completed silo with sawdust over the entire surface of the cover. Using weighting material in this manner has distinct advantages: If the cover is punctured, only a small amount of air can enter, thus limiting the area of spoilage; as the cover is rolled back during feeding, the weighting material maintains a seal over the remaining top surface of the silage that prevents air from entering and continues to prevent spoilage.

Fence silos can be successfully lined with black polyethylene or vinyl chloride plastic films. These plastics are more durable than roofing and building paper and are available at about the same cost.

The chief practical consideration in making a choice among plastic covering materials is their annual cost. Neoprene on nylon covers are relatively expensive, but are durable. The entire useful life of these covers is unknown at this time. Polyethylene and vinyl chloride films cost less but are more easily damaged, and their useful life may be short unless special care is used in handling.

DANGEROUS SILAGE GASES

Gases formed during fermentation may become hazardous when making and feeding all types of silages unless precautions are observed. The gases are heavier than air and collect readily in below-ground silos, or in enclosed space above silage in tower silos. Farmers have long known about the suffocating effect of carbon dioxide gas formed in silage. Recently, it also has been recognized that nitrogen dioxide gas is formed by high-nitrate silages and can cause a disease called nitrogen dioxide pneumonia in man and livestock. This disease has been fatal in some cases.

Some plants, such as legumes, oats, barley, wheat, corn, sorghums, many pasture grasses, and certain weeds, appear to accumulate especially high concentrations of nitrates during droughts and when grown on high-nitrate soils. When these plants are made into silage, poisonous nitrogen dioxide gas forms until a week or 10 days after filling the silo.

Precautions against hazards caused by silage gases include running the blower for several minutes before anyone enters the silo, or otherwise agitating the air to dilute gases that may be present. Carbon dioxide gas may be detected by lowering a lighted lantern into the silo. If the flame in the lantern goes out, the oxygen content of the atmosphere in the silo is dangerously low.

Nitrogen dioxide gas can be detected with starch-iodide paper, which turns blue in the presence of nitrogenous compounds. The paper can be obtained from drug stores or chemical supply houses.

FEEDING HAY CROP SILAGE

As a feed, good silage from hay crops is palatable, nutritious, and easy to handle. It can be fed with little waste. Its carotene content will keep the vitamin A content of milk from dairy cows at about the summer level throughout winter.

Hay crop silage may be used as the main source of forage in winter cattle feeding, although research results indicate that cattle do better if two or more roughages are fed. On an equal dry-matter basis, hay crop silage can be fed to replace either corn silage or hay, or it can be fed

along with these two roughages. The protein content of hay crop silage is generally higher than that of corn silage.

The feeding value of a particular silage depends on methods and treatments used in making the silage, as well as on the kinds of plants ensiled. The differences in nutritive value among silages made from various hay crops are similar to the differences found among hays made from these crops. A farm operator may use his experience in feeding hays made from different crops to judge the differences in nutritive value that can be expected when these crops are harvested for silage. Whether silage or hay, the most nutritious feed is usually made up of early cut legumes or mixtures of legumes and grasses.

Although good hay crop silage can be made by either the wilting method or the direct-cut method, certain feeding differences exist in the silages that result. For example, unwilted silage usually contains more carotene than wilted silage, because the unwilted forage is not exposed as long to weathering that destroys carotene. Wilted silage generally is more palatable than unwilted silage that has had no preservative added and often is more palatable than silage that has had preservative added.

ARS tests indicate that dairy cows will consume more dry matter from unwilted silage that has been treated with a preservative than from poor quality unwilted silage made from the same crop, but with no preservative added. However, in other tests when the quality of untreated silage was good, cows consumed equal amounts of dry matter from untreated and treated silages.

When unwilted silage is fed to cows to the limit of their appetites, dry hay should be added to the ration at the rate of 10 to 15 pounds per day or to the limit of appetite to maintain a normal roughage intake. When the silage contains from 69 to 75 percent moisture, about 1/2 pound of hay per 100 pounds of liveweight is required.

Chopping of forage, although not necessary, is desirable from the standpoint of increasing silo capacity and for convenience in storing and removing of silages. Silage quality and feeding value are improved by chopping relatively dry forage, but no marked improvement results from chopping forage of a higher moisture content.

Feeding Precautions

All silages should be fed after rather than before milking to lessen the possibility of affecting the flavor and odor of milk.

Unwilted hay crop silage may freeze in cold weather, but may be eaten by livestock without harm or loss of silage nutritive value if fed immediately after thawing. During warm weather, hay crop silage that is exposed to air spoils quickly. A uniform layer of silage about 3 inches thick should be fed daily. During cold weather, feeding may be done at a slower rate without fear of spoilage.

WHAT IS GOOD HAY CROP SILAGE?

How good, or how poor, hay crop silage is at the time a silo is opened for feeding naturally depends on the condition and kind of crop that was put in the silo, on the skill used in harvesting the crop and filling the silo, and on the efficiency of the silo in excluding air.

These factors were taken into account by a national silage evaluation committee when they recently devised the scorecard that follows for judging the feeding value of silage made of grasses, legumes, or combinations of both. The committee was made up of representatives of State agricultural experiment stations, the Agricultural Research Service, and industry. Scoring is based on quality, color, and odor of silage.

Scorecard

The quality of a silage is based mainly on the stage of maturity of the hay crop at the time of cutting. Forages cut early are more digestible and contain more protein than late-cut, stemmy, more mature forages. Presence of foreign matter, such as weeds, also lowers the quality of silage.

A natural forage color of green or slightly yellowish green is an indication of good feeding value. There may be slight variations from this color depending on the crop or the preservative added. Dark brown or charred black color indicates excessive heating caused by poor packing or forage moisture content that was too low at the time of ensiling. Molds are objectionable, and indicate the presence of too much air. Deep green or dark black colors, often in conjunction with a slimy forage, indicate damage caused by an extremely high forage moisture content.

Odor reflects the type of silage fermentation and may vary from a very mild crushed grass smell to strong ammonia or musty odors which indicate loss of nutrients. Strong odors are usually associated with unwilted silage and may, in some cases, be prevented by adding preservatives or by wilting to reduce forage moisture content. However, strong ammonia or musty odors are caused by poor air exclusion and cannot be corrected by adding a preservative.

SCORECARD FOR HAY CROP SILAGE
(Grasses, Legumes or Combinations of Both)

Sample No.____
Composition
% legume____
% grass_____

CROP QUALITY (40 points) BASED ON STAGE OF GROWTH AT CUTTING

	Possible score	Score given
1. Before blossom or early heading (fine stems high leaf content)	36-40	_____
2. Early blossom	31-35	_____
3. Mid-to-late bloom	21-30	_____
4. Seed stage (very stemmy, coarse, low leaf content)	10-20	_____

continued

PRESERVATION (60 points) BASED ON COLOR AND ODOR

A. COLOR (30 points)

		Possible score	Score given
1. DESIRABLE	Natural forage green or slightly yellowish green. Light to dark green depending on crop and/ or additive used. Red clover may have a darker color	26-30	______
2. ACCEPTABLE	Deep dark green or very yellowish-green or slight brownish green	16-25	______
3. UNDESIRABLE	Brown or black indicating excessive heating or putrefaction. Predominantly white or gray indicating excessive mold	5-15	______

B. ODOR (30 points)

		Possible score	Score given
1. DESIRABLE	Clean, pleasant with no indication of putrefaction	26-30	______
2. ACCEPTABLE	Somewhat strong, yeasty, fruity or musty, slight burnt odor, sweet	16-25	______
3. UNDESIRABLE	Strong, burnt or caramelized odor indicating excessive heating. Sliminess and a putrid odor indicating improper fermentation. Very musty or moldy odor with excessive mold visible.	5-15	______
	TOTAL SCORE	100	______

MOISTURE CONTENT: High moisture silage (75% or above) will contain less feed value per pound than lower moisture silage. High moisture may indicate excessive juice loss with loss of nutrients. However, heavy nutrient loss may result from ensiling material too dry to pack well. Moisture content can be approximated by squeezing in the hand; if juice runs free, it is high moisture.

FURTHER RESEARCH ON HAY CROP SILAGE

The fundamental processes involved in silage making have not been fully discovered. More information about them is needed for the development of modern machinery, storage structures, and preservatives for silage from hay crops.

Some of the practical problems that are now under study: How to retain the simplicity offered by direct-cut harvesting but reduce the burden caused by excessive moisture in silage made from unwilted hay crops; how to improve the herd appetite for silage from unwilted crops; and how to feed and store silage more efficiently. Also under study are the various crops and mixtures of crops used for silage.

More knowledge is needed about the basic chemical, bacteriological, and energy changes that take place during the making of silage and the effects of different crop plants on the fermentation process. Also, further information is needed to pinpoint the kinds of losses that occur in hay crop silage and when and where these losses occur.

A goal of ARS studies is to devise new methods for supplying economical, palatable, and nutritious forage when it is most needed. In its present state of development, hay crop silage fills an important role by saving a maximum amount of nutrients in the green forage crop, particularly when it is impossible to make well-cured hay.

The aim of investigators is to improve techniques that can be used by the farmer in harvesting, handling, and storing hay crops for silage, since these methods determine how much of the nutritive value of the crop is lost and therefore how closely the silage compares in composition with the green crop. Achieving this aim requires the teamwork of chemists, bacteriologists, nutritionists, engineers, and agronomists.

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